NASA KSC/Intern Project Plan – 2016 – 08/05/2016

Data Mining and Knowledge Discover
IBM Cognitive Alternatives for NASA KSC

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Abstract

Skillful tools in cognitive computing to transform industries have been found favorable and profitable for different Directorates at NASA KSC. In this study is shown how cognitive computing systems can be useful for NASA when computers are trained in the same way as humans are to gain knowledge over time. Increasing knowledge through senses, learning and a summation of events is how the applications created by the firm IBM empower the artificial intelligence in a cognitive computing system. NASA has explored and applied for the last decades the artificial intelligence approach specifically with cognitive computing in few projects adopting similar models proposed by IBM Watson. However, the usage of semantic technologies by the dedicated business unit developed by IBM leads these cognitive computing applications to outperform the functionality of the inner tools and present outstanding analysis to facilitate the decision making for managers and leads in a management information system.

KEYWORDS: cognitive computing; artificial intelligence; computational intelligence, IBM Watson

I. Introduction

NASA is dedicated not only to the exploration of the external earth space but developing of cutting edge technology resulting in significate advances in diverse fields of sciences. There have been many events experimented and collected by NASA in databases since the US space program started in fifties. This consistent dedication places NASA in an expertise level to advance and explore new challenges. However, the organization and management of the experience and information acquired for many years is crucial and necessary to solve problems and predict future events. The implementation of cognitive computing applications in the different processes where NASA KSC has built databases with robust information may help the agency to make corrections ahead of time and improve these processes reducing cost. There are real applications, as explained in [1], that can support this technology and many cognitive computing commercial systems, as reported in [2, 3], used in many fields with similar processes managed at NASA KSC.

To explore the benefits of cognitive computing it is necessary to define and review the history of this concept. Cognition is the process in humans that advocate the discovery of knowledge [4] and interpretation of the world [5]. However, there is not an approved general definition of cognition [6] even though there is considerable research into human cognition [7, 8, 9].

The concept cognitive computing originally was conceived in 1995 [10]. Since then, this concept has been elucidated diversely by researchers according to the field of study [11, 12, 13, 14]. In the last few years cognitive computing systems have increasingly gathered the attention of researchers due to the properties given by using different techniques to discover knowledge. These techniques depend mainly on the algorithms and architecture used to store data in databases. Key characteristics are utilized by algorithms to deep search databases to then make predictions with high probability rate.

This manuscript investigates the IBM cognitive analytic applications, integrated in the IBM Watson that could be used to improve the efficiency of different processes at NASA KSC.

II. Distribution and Related Research on Cognitive Computing

Cognitive computing has received different names according to the field of study, concept and definition adopted by researchers including but not limited to artificial intelligence, behavioral sciences, cognitive sciences, computer sciences, biological processing, nervous system, reasoning, decision making, cognitive informatics, neurobiology and cognitive psychology [15]. Recently, researchers in cognitive computing have focused their attention primarily on the faculties established by the objectives of the area of study. They are grouped in faculties of knowing, thinking and feeling.

A. Cognition Through Faculties of Knowing

There is numerous studies in computer system with faculty of knowing [16]. Mathematical frameworks [17] are frequently used to stablish an object-attribute relationship for knowledge manipulation as done in algebra to then formalize knowledge. In this type of cognition model a prototype of knowledge is created, then irrelevant knowledge is discriminated based on attributes and finally the knowledge is generalized and ruled in an elaborated algorithm in real time [18]. Causal relationships and fuzzy logic [19, 20] models represent the knowledge defined for concepts integrated into a cognitive map.

B. Cognition Through Faculty of Thinking

Cognitive computing systems with the faculty of thinking are able to bring solutions independently by comparing causal-concept in a trained database with information and algorithms [21, 22]. Among these concepts analysis systems are music, digit, and eye recognition and detection [23, 24]. Additionally, cognitive frameworks based on neurons enable the faculty of thinking in systems known as computer machinery [25, 26]. It does take into consideration both conscious and a subconscious cognitive analytics that admit external events and responding consequently. In the end, the learning system performances an acknowledgement loop to develop new learning.

C. Cognition Through Faculty of Feeling

There are several studies dedicated to develop cognitive computing model with the faculty of feeling. Many of these studies are based on ideology for self-reasoning, facial expression analysis for social acceptance and personality, emotions and moods for self-control. The final product from these analyses result in an emotional-intelligence archetype to model emotional situations [27, 28, 29]. However, descriptive mathematics are used to characterize perception and inference engines for this emotional model [30]

III. What is Watson and How it can Help to Improve Directorates at NASA KSC

Watson is a blend of multiple approaches of faculties reviewed above to develop cognitive computing for establishing knowledge. It uses probabilistic analysis techniques with semi-structured and structured approaches including more than 100 natural language reasoning techniques to represent knowledge [31, 32]. This model is able to manage a lexical analysis on a considerable compilation of information in a database or on the web. The analysis techniques of this prototype of cognitive knowledge results in a well-accepted set of solutions and their possible relationships for open-domain questions.

The NASA KSC Directorates where this study may be useful to make efficiency improvements with the cognitive computing IBM Watson applications are the following: Safety and Mission Assurance, Commercial Crew Program, Launch Services Program, Ground Systems Development and Operation and Exploration Research and Technology Program. The IBM Watson cognitive computing applications used to enhance the functionality of the above mentioned NASA KSC Directorates are the following: Alchemy API, Concept Insights, Dialog, Conversation, Document Conversion, Language Translation, Natural Language Classifier, Personality Insights, Relationship Extraction, Retrieve and Rank, Speech to Text, Text to Speech, Tone Analyzer, Tradeoff Analytics, Visual Recognition, Cognitive Commerce, Cognitive Graph, Cognitive Insights.

Table 1 shows potential applicability of IBM Watson cognitive computing tools to each of five above mentioned Directorates. IBM Watson cognitive computing tools functionalities are analyzed below for each Directorate at NASA KSC.

Table 1. IBM cognition computing tools applicable to NASA KSC Directorates

NASA Directorates / IBM Services	SA Safety and Mission Assurance (SMA)	FA Commercial Crew Program (CCP)	VA Launch Services Program (LSP)	LX Ground Sys. Developm. and Operations (GSDO)	UB Exploration Research and Technology Program (UB)
Alchemy API	X	X	X	X	X
Concepts Insights	X	X	X	X	X
Dialog	X	X	X	X	X
Conversation	X	X	X	X	X
Document Conversion	X				X
Language Translation	X				X
Natural Language Classifier	X	X	X	X	X
Personality Insights	X				X
Relationship Extraction	X	X	X	X	X
Retrieve and Rank	X	X	X	X	X
Speech to Text	X	X	X	X	X
Text to Speech	X	X	X	X	X
Tone Analyzer	X		X	X	X
Tradeoff Analytics	X	X	X	X	X
Visual Recognition	X		X	X	X

A. Safety and Mission Assurance

This Directorate provides guidance to the organization and surveillance and analysis to complete engineering reviews. This office provides S&MA services for programs, projects, and all activities that lead up to certifying flight readiness at KSC including safety, reliability, software assurance, and quality engineering and assurance support. This is accomplished through ongoing surveillance, consultation, integration, trending, analysis, independent assessments, audits, and S&MA policy and requirements development and implementation [33].

1. ***Business & Administrative Office:*** This office provides support, contract technical management, resources management and business/program integration, workforce planning, employee performance evaluation management, monitoring contract performance This office do the analysis of both financial and labor resources [33]. Interactive speaking/guidance applications can be implemented as chat applications were built using Bluemix in GitHub [34]. Support from this office to other offices and customer can be improved with Dialog, Conversation, Natural Language Classification and Retrieve and Rank tools of IBM Watson. Also, Alchemy API, Concepts Insights and Relationship Extraction for monitoring contract performance. Visual Recognition, Tone Analyzer, Speech to text and Language Translation will be useful for testing and analysis [35, 36, 37].

2. ***Exploration Research and Technology Office:*** This office provides management and integration of S&MA requirements for payload flight operations and associated ground interfaces and resources, resolves technical S&MA issues. This office assures that the flight and ground S&MA requirements are generated, validated, integrated, scheduled, and implemented. Also, provides support risk management processes, to identify, assess, eliminate, and mitigate risks [33]. Cognitive tools including Dialog, Conversation, Natural Language Classifier and Retrieve and Rank can be useful for support processes to resolve technical issues. Concept Insights and Retrieve and Rank useful for integration e processes. Alchemy API, Concepts Insights and Relationship Extraction tools especially used for verification and validation. And Tradeoff Analytics tool offers great help whether risk mitigation, as seen in [38, 39].

3. ***Commercial Crew Office:*** The Commercial Crew Office provides management and integration functions in the Commercial Crew Program (CCP) life-cycle including budget to support the program and the development of programmatic requirements consistent with Agency policy and program requirements. The Office monitors the implementation to ensure compliance with applicable S&MA requirements and processes including operational and system safety engineering, quality engineering, quality assurance, reliability engineering, and software assurance support [33]. An interactive communication to provide a guidance of

policies and processes can be provided by Dialog, Conversation, Natural Language Classification and Retrieve and Rank. Integration can be improved with Concept Insights and Retrieve and Rank IBM cognitive tools. And verification and validation can optimized with Alchemy API, Concepts Insights and Relationship Extraction [39].

4. ***Launch Services Division:*** The Launch Services Division provides management and integration function for all S&MA activities associated with the LSP. This division independently assess related processes, operations, and programs used in the procurement, design, production/manufacturing, launch vehicle and related spacecraft processing and integration, prelaunch, launch operations, and post-launch activities. This Division provides services in operational and system safety, quality engineering, quality assurance, reliability engineering, mission assurance, risk management, and contingency planning throughout the life cycle of Expendable Launch Vehicles (ELVs) and interfaces between these launch vehicles and related spacecraft [33]. Support and provides technical enhancements approaches for the different processes thru the tools Dialog, Conversation, Natural Language Classification and Retrieve and Rank. Integration can be provided with Concept Insights and Retrieve and Rank. Therefore, verification and validation for each process can be provided with Alchemy API, Concepts Insights and Relationship Extraction. Risk analysis can be improved with the Tradeoff Analytics tool. Accessing operational fields to provide a diagnostic for risk management may implies measuring and quantify magnitudes that can be obtained with Tone Analyzer, Speech to Text and Visual Recognition tools [40, 41, 42].

5. ***Institutional Division:*** The Institutional Division contributes with management and integration of S&MA activities necessary to protect visitor, employees and NASA assets at KSC from the hazards posed by institutional laboratory, engineering-scale test, construction, partner, or other institutional operations conducted at KSC. The Institutional Division measures and evaluates the effectiveness of these capabilities to provide safety and quality programs for KSC and a risk management plan [33]. Integration of activities can achieved using tools Concept Insights and Retrieve and Rank. Therefore, testing and evaluation for the different processes can be optimized with Alchemy API, Concepts Insights and Relationship Extraction. Risk analysis can be improved with the Tradeoff Analytics tool. Risk management may implies measuring

and quantify magnitudes that can be obtained with Tone Analyzer, Speech to Text and Visual Recognition tools [40, 41, 42].

6. ***Ground Systems Development and Operations Division:*** The Ground Systems Development and Operations Division provides management and integration for S&MA activities associated with the GSDO Program and interfaces to Space Launch System and Orion Programs including budget, production operations and flight test for the Orion program. This office assist program/project/planning offices in the development of programmatic requirements consistent with Agency policy and program requirements. They provides coverage for operational and system safety, procurement and acquisition, quality engineering, quality assurance, reliability engineering, software assurance, mission success, and risk management, as required [33]. Concept Insights and Retrieve and Rank tools can optimize the integration process of activities. Therefore, evaluation for the different processes can be achieved with Alchemy API, Concepts Insights and Relationship Extraction tools. Risk analysis can be improved with the Tradeoff Analytics tool. Testing activities in this division implies measuring and quantify magnitudes that can be collected with cognitive tools Tone Analyzer, Speech to Text and Visual Recognition tools [40, 41, 42].

7. ***Technical Management Office:*** The Office is responsible for the technical implementation of the budget and resources for NASA activities providing S&MA guidance, consultation, assistance, and support. The Office also uses this expertise to lead special projects and integrate technical positions for the directorate. In addition, the Office coordinates S&MA policy and requirements expertise within the S&MA directorate and all directorates across the Center. The Office researches, develops, reviews, analyzes, and coordinates interpretation of S&MA policy and requirements [33]. Guidance and technical assistance for the different processes can be enhanced thru the tools Dialog, Conversation, Natural Language Classification and Retrieve and Rank. Concept Insights and Retrieve and Rank can collaborate with the integration of processes. Therefore, verification and analysis of policies and requirements can be done with Alchemy API, Concepts Insights and Relationship Extraction [40, 41].

B. Commercial Crew Program (CCP)

The objective of the Commercial Crew Program (CCP) is to administer the resources for the development of commercial, entire transportation system to carry the crews in a safety manner from and to the International Space Station. This Directorate, also, manages the Crew Transportation System certification process and the supporting technical and programmatic Partner integration functions [43].

1. ***Program Control and Integration***: This office is in charge of activities related to budget and civil service resource management for CCP, including integration and budget formulation, cost threat and risk management, funds distribution and control, change control and execution and analysis [43]. Retrieve and Rank and Concept Insights IBM Watson cognitive computing tools can be useful to integrate assessments of Commercial Partners progress toward meeting certification requirements defined and selected with help of Concept Insights and Relationship Extractions tools. Budget, and cost threat can be computed with the Conversation tool for cost effective solutions but risk management can be modulated with the preexisted concepts stablish by CCP thru Concept Insights against public domain concepts or results given by Alchemy API and then be mapped in a final analysis with Retrieve and Rank and Relationship Extraction with a drastic analysis adhered to the goals and criteria that matters to this particular office done by Tradeoff Analytics as seen in [42, 44].

2. ***Systems Engineering and Integration (SE&I):*** This office makes associated technical recommendations for the CCP manager to facilitate the performance of Commercial Partners toward meeting certification requirements to achieve system safety requirements, design and construction standards and systems interface requirements [43]. As seen before, a guidance and support on technical recommendations can be provided by IBW Watson tools Dialog, Conversation, Natural Language Classification and Retrieve and Rank. Verification and validation of the integration of assessments performed with requirements stablished can be

worked with Concepts Insight, Alchemy API, Relationship Extraction and Retrieve and Rank [40, 42].

3. ***Mission Management and Integration (MM&I):*** This office establish policies, processes and specific requirements relative to mission integration and operations. Mission integration includes collaboration between ISS, CCP and the commercial Partners for allocations, manifest, consumables, crew provisioning and cargo. Mission operation includes technical support needs for preparation and execution of flight test of Commercial Partners Launch vehicles and ISS crew transportation service [43]. An interactive communication to provide a guidance of policies and processes can be provided by Dialog, Conversation, Natural Language Classification and Retrieve and Rank. Additional implementation of Text to Speech and Speech to Text tools are made according to technical support application in the flight test and operation required. For mission integration is necessary to implement a solution with Concept Insights and Retrieve and Rank [39, 45].

4. ***Spacecraft Office:*** The Spacecraft office define requirements for spacecraft system certification assessment, leveraging technical discipline insight into the development of the Commercial Partners spacecraft and associated products including design, manufacture, hazard analysis, test, certification, schedules and approaches [43]. Support and orientation on technical implementation aspects can be provided by IBW Watson tools Dialog, Conversation, Natural Language Classification and Retrieve and Rank [40, 42].

5. ***Launch Vehicle Office:*** The Launch Vehicle Office is responsible for launch vehicle requirements definition and for launch system certification assessment, leveraging insight into the development of the Commercial Partners launch vehicle and associated products including design, manufacture, hazard analysis, test, certification, schedules and approaches [43]. These guidance and support on technical implementation approaches can be provided by IBW Watson tools Dialog, Conversation, Natural Language Classification and Retrieve and Rank [39, 42].

6. ***Integrated Performance Office (IP):*** The IP office performance analytical assessments of the Commercial Partners progress toward meeting integrated system performance requirements, and provides the associate technical recommendations to the CCP manager. These office integrates systems performance requirements and approves the corresponding verifications and validations [43]. Support and guidance on technical enhancements approaches can be provided by IBW Watson tools Dialog, Conversation, Natural Language Classification and Retrieve and Rank. Integration can provided with Concept Insights and Retrieve and Rank. And verification and validation can provided with Alchemy API, Concepts Insights and Relationship Extraction [39, 40, 42, 44].

7. ***Ground and Mission Operations Office (G&MO):*** The G&MO office define requirements for related operations control center certification assessments, oversight technical requirements of Commercial partners for ground processing and flight operations including flight strategies, flight products and technical support [43]. Guidance and support on technical implementation approaches can be provided by IBW Watson tools Dialog, Conversation, Natural Language Classification and Retrieve and Rank [42, 45].

C. Launch Services Program (LSP)

The LSP Directorate manages partnerships with other Government agencies and launch providers including the Vandenberg Air Force Base (VAFB). Also, this office In addition, the LSP manages relationships with emerging launch providers, and obtains risk mitigation strategies for vehicle certification of all the missions with NASA [46].

1. ***Administrative Office:*** The Administrative Office contribute with assistance in administrative services to implement requirements for human resources and other administrative functions. Also, this office coordinates and provide training in administrative areas [46]. IBM Watson can provide guidance and support on administrative activities with Dialog, Conversation, Natural Language Classification and Retrieve and Rank tools the implementation of administrative requirements can be supported by Concept Insights and Relationship

Extractions tools. Requirements for human resources may be improved with tools Personality Insights, Relationship Extraction, Tone Analyzer and Tradeoff Analytics [35, 36, 40].

2. ***Office of Launch Director:*** The Office of Launch Director is responsible for assuring that all safety and standards of launch services and launch schedules in all facilities are accomplished for all customers including the United States Air Force (USAF). These is achieved managing manifest policies thru manifest forums [46]. IBM Watson provides solution for assuring accomplishments of activities by verifying and validating with Alchemy API, Concepts Insights and Relationship Extraction. Manifest of policies and forums to inform and receipt feedback form customers can be achieve with Dialog, Conversation, Natural Language Classification and Retrieve and Rank [39, 42, 45].

3. ***Program Planning Office (PPO):*** The Program Planning Office (PPO) manages crosscutting planning investments for technical studies of products and services and enhancement for the LSP outreach, and management of the LSP industrial engineering network. Also, the PPO office surveillances, oversees, audits, advises and guides these investments and programmatic studies that spin off from the strategic processes [46]. The cognitive computing system of IBM Watson can crosscutting planning for the technical improvement of the LPS with the tools Alchemy API, Concepts Insights, Relationship Extraction and Tradeoff Analytics. And guiding can provided with Dialog, Conversation, Natural Language Classification and Retrieve and Rank tools [35, 45, 47].

4. ***Flight Projects Office (FPO):*** The Flight Projects Office (FPO) is responsible for planning and implementation of technical, schedule, and budget requirements for all NASA expendable launch vehicle missions, from spacecraft conception through launch and mission success determination. Mission Managers serve as the primary point of contact to spacecraft customers and launch service contractors for all. This office is responsible for ensuring consistent implementation of effective processes across missions [46]. IBM Watson cognitive computing system can facilitate the FPO office the planning and implementation of technical, schedule,

and budget requirements for all NASA activities with Alchemy API, Concepts Insights, Relationship Extraction and Tradeoff Analytics tools. Also, assuring implementation of effective processes with Alchemy API, Concepts Insights and Relationship Extraction [38, 39, 45]

5. ***Program Business Office:*** The Program Business Office (PBO) plan and execute the LSP support requirements and flight project customer requirements. The functions provided by this office includes financial management, integration and insight of the launch services projects across multiple Centers [46]. The cognitive computing system lunch by IBM Watson can facilitate the PBO office the planning and execution the LSP support requirements with Alchemy API, Concepts Insights, Relationship Extraction and Tradeoff Analytics tools. Integration can provided with Concept Insights, Retrieve and Rank and Tradeoff Analytics across multiple centers [35, 42, 45].

6. ***Infrastructure Management Division***: The Infrastructure Management Division provides integration management and communications and telemetry insight for launch vehicle/spacecraft. This office assures safe, cost-effective, and timely integration of spacecraft requirements and ground systems services. They also develops and implements program policies [46]. IBM Watson offers Concept Insights and Retrieve and Rank tools for integration management, Dialog for cost-effective requirements. Additionally, Dialog, Conversation, Natural Language Classification and Retrieve and Rank are useful for development and implementation and guidance of program policies. Finally, Visual Recognition, Tone Analyzer would help in telemetry engineering insight [38, 42, 45].

7. ***Fleet and Systems Management Division:*** The Fleet and Systems Management Division supplies technical integration and leadership for the LSP. Verifies, assures and approves the appropriate requirements for technical implementation for a safe and successful launch in accordance with the Launch Vehicle Technical Oversight assisting spacecraft customers throughout mission life cycles [46]. IBM Watson cognitive tools can assist NASA KSC's

spacecraft customers throughout mission life cycles in interactive communication and verification and validation with Dialog, Conversation, Natural Language Classification and Retrieve and Rank and Alchemy API, Concepts Insights and Relationship Extraction respectively. While the technical integration can be achieved with Concept Insights and Retrieve and Rank [38, 39, 45].

8. ***Flight Analysis Division:*** The Flight Analysis Division verifies and validate requirements demanded for independent NASA assurance of ELV for a safe and successful launch according to the established launch vehicle certification. The Division assists spacecraft customers in the definition of mission requirements and independently verifies contractors' compliance with mission requirements. The Environments and Launch Approval Branch provides leadership and expertise in aerodynamics, electromagnetic interference/radio frequency analysis, thermal and fluids analysis, and nuclear launch approval [46]. Cognitive tools Alchemy API, Concepts Insights and Relationship Extraction are especially used for verification and validation in this case and guidance can be provided with Dialog, Conversation, Natural Language Classification and Retrieve and Rank [38, 39, 45].

D. Ground System Development and Operations (LX)

GSDO manages schedule, cost and technical content of projects for Orion, SLS, and SLS payloads. Also develops ground systems and ground operations processes to perform ground operations at the launch, landing, and recovery sites required to accomplish receiving, ground processing, assembly and integration, integrated and interface testing, launch operations, recovery, disintegration, refurbishment, disposal, pad abort, and search and rescue operations [48].

1. ***Command Control and Communications Office (LX-C):*** This office Manages Systems Engineering, Integration, and Operations. This includes the development, operation, and sustainment infrastructure modernization of the Launch Control Center, including software and hardware development for Spaceport Command and Control Subsystems (SCCS), Ground Systems Equipment (GSE) software [48]. IBM Watson offers Concept Insights and Retrieve

and Rank tools for integration of processes. And operational tools Visual Recognition, Tone Analyzer, and Speech to text and Language Translation for software and hardware development [38, 45].

2. ***Program Logistics Office (LX-L):*** This office provide guidance, integration and logistics budget formulation. This formulation occurs during requirements development and operations planning in support for launch vehicle processing, spacecraft integration, and launch and landing including supply, support, packaging, handling, storage, and transportation for development and operations. This office manages the inventory control and storage of work-in-process items being manufactured during development and items used to support of processes managed by Validation and Verification (V&V) [48]. Support from this office to other offices and customer can be optimized with Dialog, Conversation, Natural Language Classification and Retrieve and Rank tools of IBM Watson. Also, Concept Insights and Retrieve and Rank cognitive tools for integration of processes. Therefore, Alchemy API, Concepts Insights and Relationship Extraction for verification and validation [38, 39, 42, 45].

3. ***Program Planning and Control Division (LX-B):*** The PP&C Division manages the budget and integration of funding allocated to GSDO, performance of financial analysis for all elements for the Program and projects. Also, this division manages developing and managing integrated programmatic products and functions, such as configuration management, risk management, programmatic integrated scheduling across the Program and projects [48]. Cognitive tools as Concept Insights and Retrieve and Rank cognitive tools can help in the integration of processes. Therefore, the tools useful for verification and validation processes are Alchemy API, Concepts Insights Natural Language Classification, Relationship Extraction and Retrieve and Rank. Tradeoff Analytics tool offers great help with risk mitigation or crossover analysis [38, 38, 42, 44, 45].

4. ***Systems Engineering and Integration Division (LX-S):*** This division provides technical interfaces to SLS and Orion for cross-program technical integration and manages GSDO's technical processes. The Division leads the development and management of the GSDO programmatic development requirements and vehicle processing and test requirements. This division establishes Validation and Verification (V&V)'s requirements across the program. This office provides the development and administration of technical processes and tools for execution of Program product development and technical reviews and Program operational and vehicle processing activities [48]. Concept Insights and Retrieve and Rank cognitive tools are useful for integration of processes. Also, Alchemy API, Concepts Insights and Relationship Extraction for verification and validation. And operational tools for testing and development of technical processes as Visual Recognition, Tone Analyzer, Speech to text and Language Translation will be useful [38, 39, 42, 44, 45, 47].

5. ***Operations and Test Management Division (LX-O):*** This division plan and manages ground operations and associated capabilities for SLS, Orion, SLS payloads and other spaceport customers that plan to use GSDO facilities or capabilities. This division supports flight systems design, production, and ground systems development and operations. The Division is responsible for the management, scheduling, and implementation of activities associated with processing, testing, launch, landing, and recovery of Orion flight vehicles and payloads flying on the SLS [48]. Support from this office to other offices and customer can be improved with Dialog, Conversation, Natural Language Classification and Retrieve and Rank tools of IBM Watson. Also, Concept Insights and Retrieve and Rank cognitive tools for implementation of activities. Also, Alchemy API, Concepts Insights and Relationship Extraction for testing. Due to this division manages operational activities then Visual Recognition, Tone Analyzer, Speech to text and Language Translation will be useful for testing and development of technical processes [38, 39, 42, 45, 47].

6. ***Project Management Division (LX-D):*** This division provides guidance, planning, coordination and integration in the areas of project cost, schedule, and technical including the development and maintenance of project requirements, the execution of trade studies and technical assessments, and the management/oversight during project implementation and

verification phases for development and modernization of projects. Project Management leads and/or supports the execution of V&V activities within and across Elements [48]. Guidance can be optimized with Dialog, Conversation, Natural Language Classification and Retrieve and Rank tools of IBM Watson. Integration in the areas can be improves with Concept Insights and Retrieve and Rank cognitive tools. Alchemy API, Concepts Insights and Relationship Extraction for verification and validation. And tradeoff analysis can be used for execution of trade studies and technical assessments [39, 40, 41, 42].

E. Exploration Research and Technology Program (UB)

This Directorate serves as a technological interface between KSC and all the space programs associated to NASA as ISS, SLPS, AES, and ST. This interface includes management and implementation of schedule and technical cost requirements for all ground processing elements, payloads and orbital replacement units necessary for research and technology projects and programs for the space exploration. The organization provides guidance, integration, and assures program requirements with technical and financial management [49].

1. ***Utilization and Life Sciences Office (UB-A):*** This office provides support to payload developers. They manages space life sciences projects during the whole life cycle including design, integration of science-to-flight hardware, manifesting, flight operations products, ground controls, and post-flight processing. In order to ensure the Programs organization is meeting customer expectations, this office collects customer's feedback data [49]. Concept Insights and Retrieve and Rank can be provided integration. Support to payload developers can be achieved with IBW Watson tools Dialog, Conversation, Natural Language Classification and Retrieve and Rank. And Personality Insights can added to collect customer's feedback data [39, 45].

2. ***Program Planning and Control Office (UB-B):*** This office monitors and integrates budget and requirements of all organization workforce, products and activities supporting the Center

for exploration research and technology programs. This office also provides verification and endorsement of activities, configuration management, policy administration, planning, organization's risk management analysis and IT security that support Exploration Research and Technology Programs systems [49]. Integration and monitoring can be provided with Concept Insights, Relationship Extraction and Retrieve and Rank tools. Verification and validation can provided with Alchemy API, Concepts Insights and Relationship Extraction. And Tradeoff Analytics can be added for risk management analysis [38, 39, 45, 47].

3. ***Mission and Support Office (UB-C):*** The Office provides management, implementation of logistic requirements, flight hardware processing and technical resource integration for assigned projects. Also, this office supports warehouse operations and maintenance in organizations at KSC. This may include special testing and integration of payload components that supports of Exploration initiatives [49]. Support for warehouse operations and maintenance can be provided with Dialog, Conversation, Natural Language Classification and Retrieve and Rank tools. Implementation and integration can be optimized with Concept Insights, Relationship Extraction and Retrieve and Rank tools. And testing can be provide with Speech to Text, Tone Analyzer and Language Translation tool [39, 42, 44].

4. ***Science and Technology Projects Division (UB-R):*** This division provides project management and investigation in NASA KSC scientific laboratories where the agency develops studies, designs, data, technology, flight support, and knowledge for internal and external customers of terrestrial and space projects [49]. Implementation of investigations can be optimized with Concept Insights, Relationship Extraction, Retrieve and Rank tools, Language Translation, Document Conversion. Support for internal and external customers can be provided with Dialog, Conversation, Natural Language Classification and Retrieve and Rank tools [39, 42, 45].

5. ***Research and Technology Management Office (UB-T):*** This office provides management of technology development programs and supports technology development activities at KSC. This is done by identifying technology requirements, providing guidance and integration of technology developments on technology investment decisions. Also, this office seeks for new avenues to enhance KSC's technology developments maintaining technology road maps and

investment strategies. This office provides tracking, measuring, and updating of technology development activities, risk mitigation analysis, patent applications and software usage agreements [49]. Integration of technology developments can be implemented with Concept Insights, Relationship Extraction and Retrieve and Rank tools. Guidance for technology development activities can be provided with Dialog, Conversation, Natural Language Classification and Retrieve and Rank tools. Tracking can be optimized with Speech to Text, Tone Analyzer and Language Translation tool. And for risk mitigation analysis Tradeoff Analytics tool can be added [39, 40, 41, 42, 45].

IV. How the Proposed System Architecture is Integrated?

In this study, the system architecture integrates both networks the web server and Wireless Sensor Network (WSN). And they both are integrated to a database server for inquiring and updating information of events in different places of work, as seen in Figure 1. In this figure are shown laptops, desktops, tablets and cellphones distributed in NASA KSC facilities and employees who have different levels of access to retrieve and feed information from and to the linked encrypted service web server.

Similarly, a WSN of visual and auditory sensors assigned to sense specific technical processes abroad the KSC can be organized into a cooperative network, as explained in [50], to feed the KSC database server. The KSC database is linked to the machine learning database where the IBM Watson cognitive computing system resides. Each sensor in this WSN needs a long life battery, a microcontroller and flash memory to communicate with the database server and program duties for each specific process needed at NASA KSC. Electromagnetic interference filter feature may be need for these sensors to avoid noise for false events, as shown in [51]. Each sensor installed in this system must provide updated information to the final user by feeding the database and machine learning servers in real time thru the WSN.

This architecture joins all KSC facilities associated to the center where management system can be implemented. Laptops, desktops computers, smart cellphones, laptops and sensors

are hock up with the KSC web server that at the same time is connected to the KSC database and other NASA centers servers in real-time. As an option, each Directorate at NASA KSC can a back-up web server to register and keep record of all events occurred. This redundancy will assure that NASA KSC have evidence in case of outreach, cybersecurity attacks or accidents.

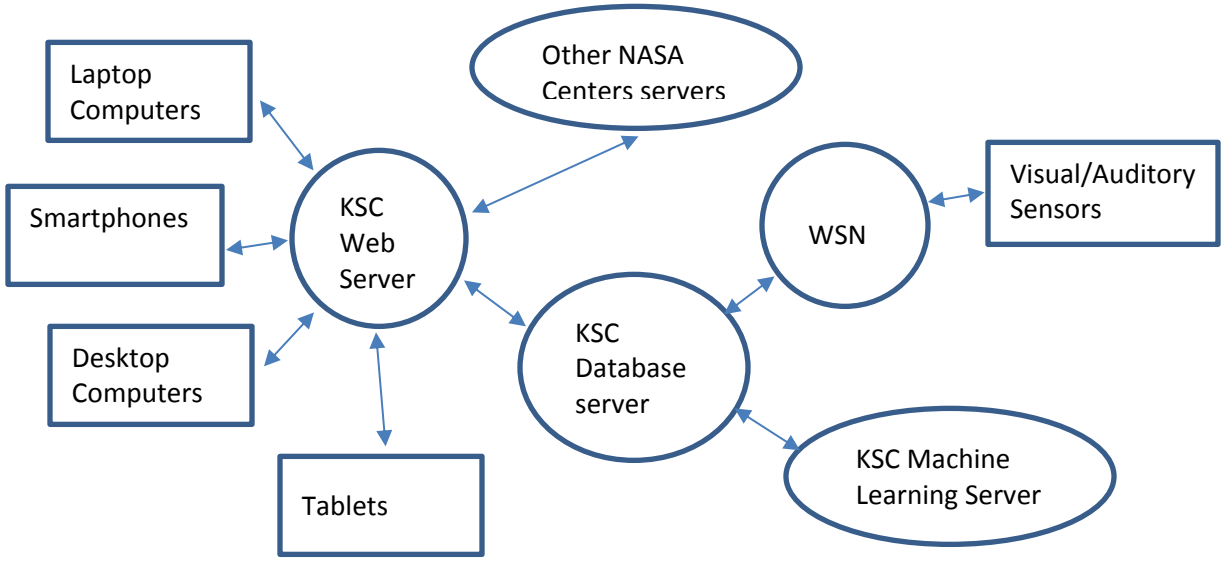
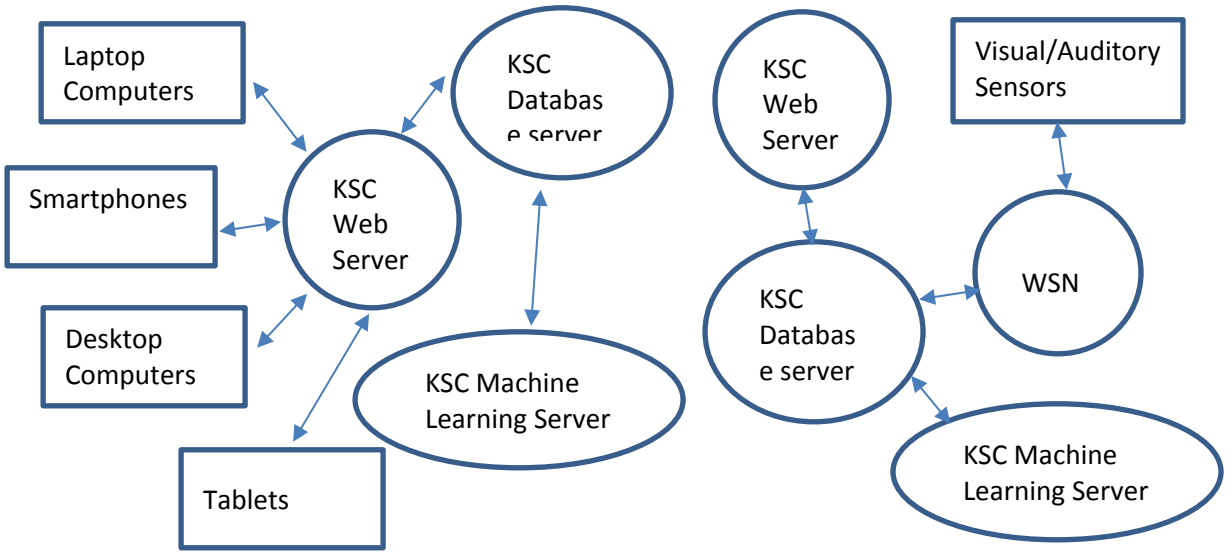


Fig. 1. The overview of the system

V. How the Cognitive System Can be Implemented?

Watson tools are distributed mainly in two groups which indicate their usage in the different offices at NASA KSC. The implementation of the IBM Watson tools can be made according to this distribution. One group of the structure can manage knowledge related to guidance, integration and verification and validation of administrative processes thru computers, cellphones and tables by retrieving and feeding from and to the KSC and machine learning databases, as seen in Figure 2a. The other group that is in charge of feed the database and machine learning servers with measurements and technical behavior of different processes, as sown in Figure 2b.



(a) (b)

Fig 2. (a) Structure managing administrative processes thru computers, cellphones and tables, (b) structure where KSC database and machine learning servers storage and process measurements and technical behavior of different processes respectively.

VI. What and How Tools are Useful in the Processes?

Administrative Processes: The first group is dedicated to administrative duties in the aerospace agency and helps the user with the guidance of internal process, however it is an input mechanism to feed the KSC database server with fresh information useful for the self-learning learning in the Machine Learning server. In this process is where an interactions user-machine and users-users are generated and enable the cognitive system to verify, validate, compare and rank answers as accurate as possible to user questions.

There are three subgroups under the first group that can be distributed according to the type of process the cognitive tools are more useful. A first subgroup of tools can help the user with guidance of technical instructions and concepts. Therefore, Dialog enables applications to use natural language to then automatically respond to user questions,, Conversation to automate interactions with more than one user, Natural Language Classification to return the top matching

answers to questions with high probability of accuracy. However, Retrieve and Rank helps users to find the most relevant information for their query by using a combination of search and machine learning algorithms, as shown in figure 3. Additional tools are suggested in this architecture in case of translation of languages and interpretation of type of communication between the user and the information storage in the NASA KSC database server. These tools are Text to Speech, Speech to Text and Language Translation.

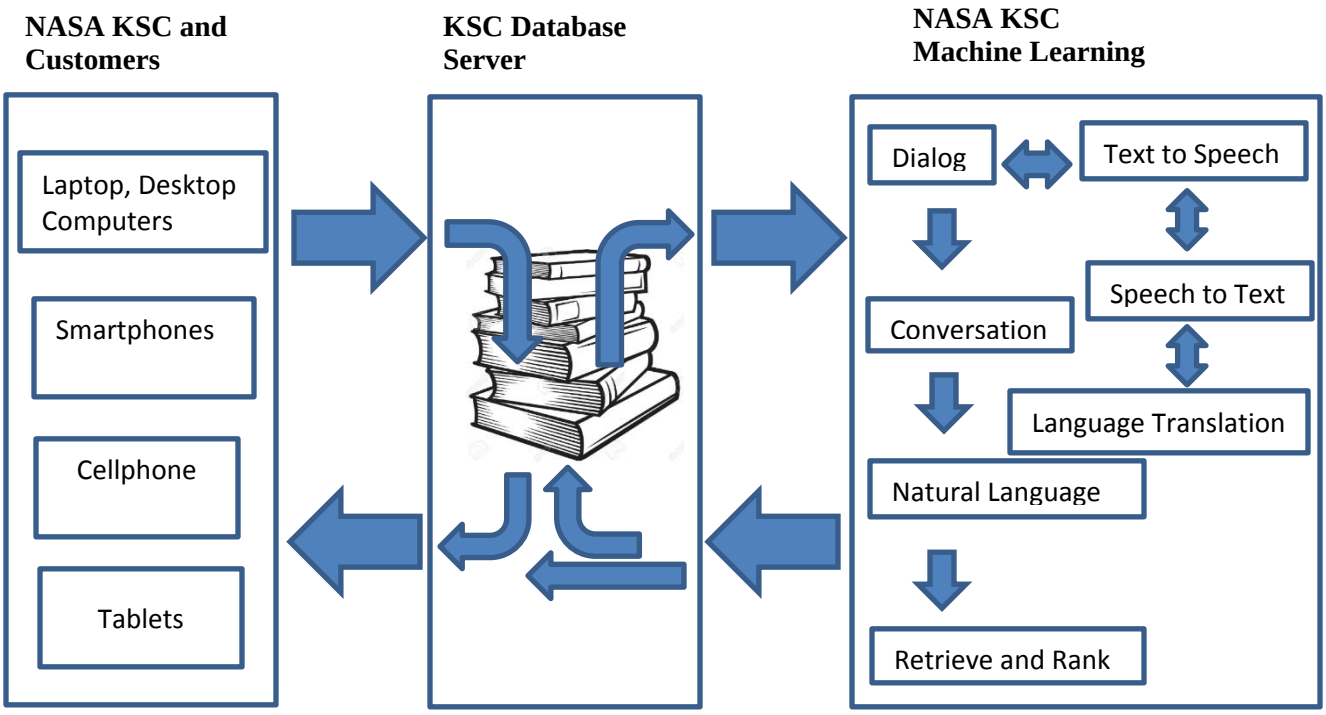


Figure 3. Diagram with interactive communication to provide guidance between offices or offices and customers at NASA KSC and other centers.

A second subgroup convenient to integrate processes uses Concept Insights to search for documents that are relevant to a concept or collection of concepts by exploring the explicit and implicit links and Retrieve and Rank which uses machine learning algorithms to find and organize the information in a most relevant manner, as seen in figure 4. Due to the integration process requires an interaction between the user, the KSC database server and the NASA Machine Learning server, the guidance process tools described above could be incorporated to this process.

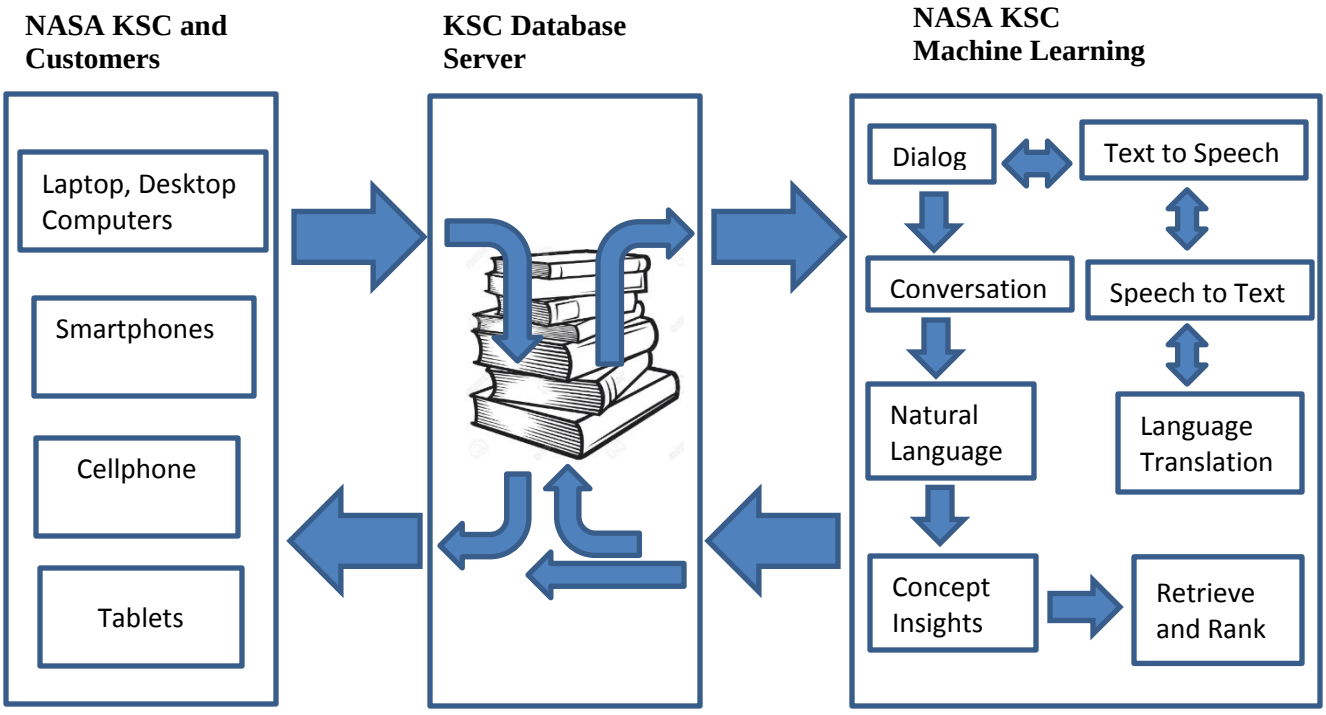


Figure 4. Diagram with interactive communication to provide integration between processes at NASA KSC.

A third subgroup with favorable tools for verification and validation processes are Alchemy API, Concepts Insights Natural Language Classification, Relationship Extraction and Retrieve and Rank, as shown in figure 5. Tradeoff Analytics tool offers can great help with risk mitigation or crossover analysis if it is necessary. As explained in integration process, the guidance process tools described above can be incorporated to this process since the verification and validation process requires an interaction between the user, the KSC database server and the NASA Machine Learning server.

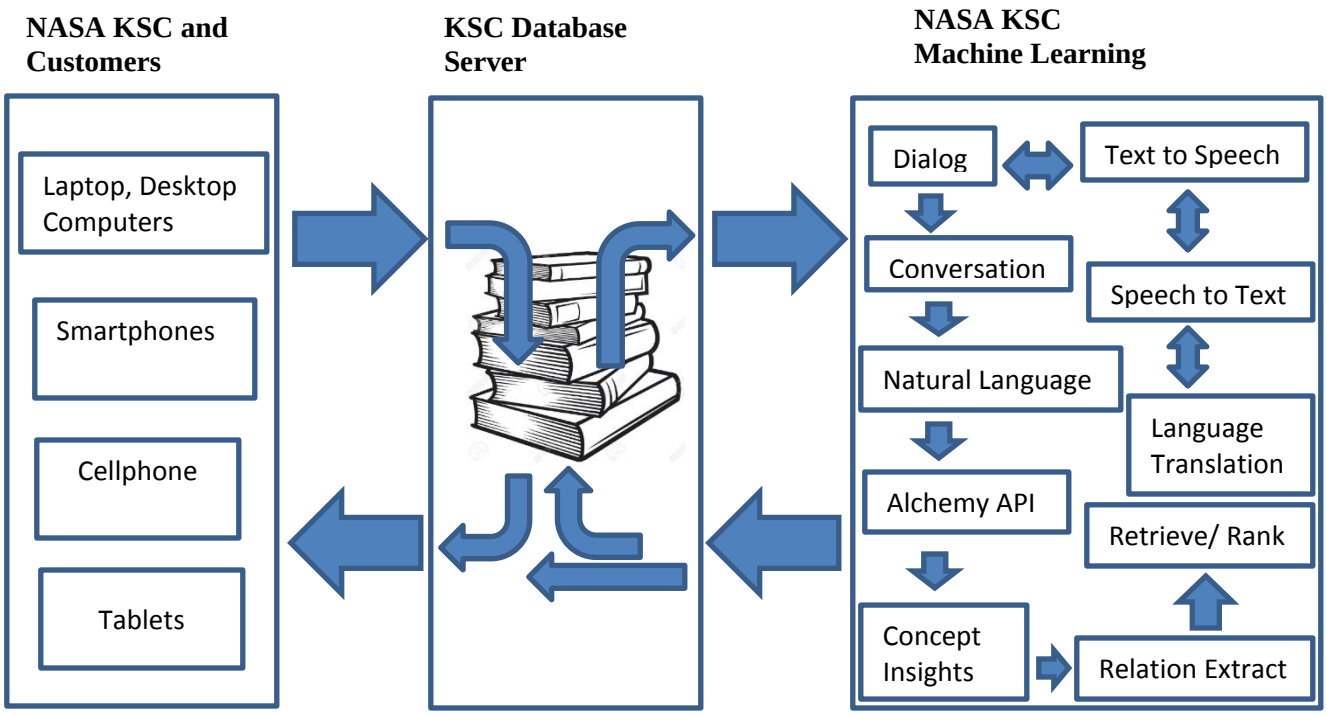


Figure 5. Diagram with interactive communication to provide verification and validation of internal processes at NASA KSC.

Operational processes: The second group principal responsibility is to collect operational reading and measurements of events that take place in processes, mechanisms and devices including spacecrafts and Lunch Vehicle Base and Platforms. These events are collected by visual and auditory sensors to then feed and built the KSC database. This information is then used by the KSC Machine Learning server for analysis and increasing its knowledge. This operational big data is them used by NASA employees and customers from all the space agency centers to make smart decisions. In this process, auditory sensors signals can be given to a Speech to Text tool and then taken by Tone Analyzer or even to Language Translation to then being analyzed, classified and ranked by other tools as seen in administrative processes above. Tone Analyzer tool is made for cognitive linguistic analysis to identify a variety of tones at both the sentence and document level, however the number of tones is limited. A Language Translation can be implemented instead of Tone Analyzer whether the variety of tones given by the specific operational process becomes to be substantial. The same principle can be apply for visual detection thru visual sensors. In this

case, visual signals can be taken by the Visual Recognition IBM Watson tool and then recognized by Tone Analyzer or Language Translation tools as define for auditory sense cases. Operational processes big data is storage in the NASA KSC database and analyzed by algorithms placed in the Machine Learning server. The same administrative tools seen before are implemented in the diagram, shown in figure 5, of this process for administrative usage.

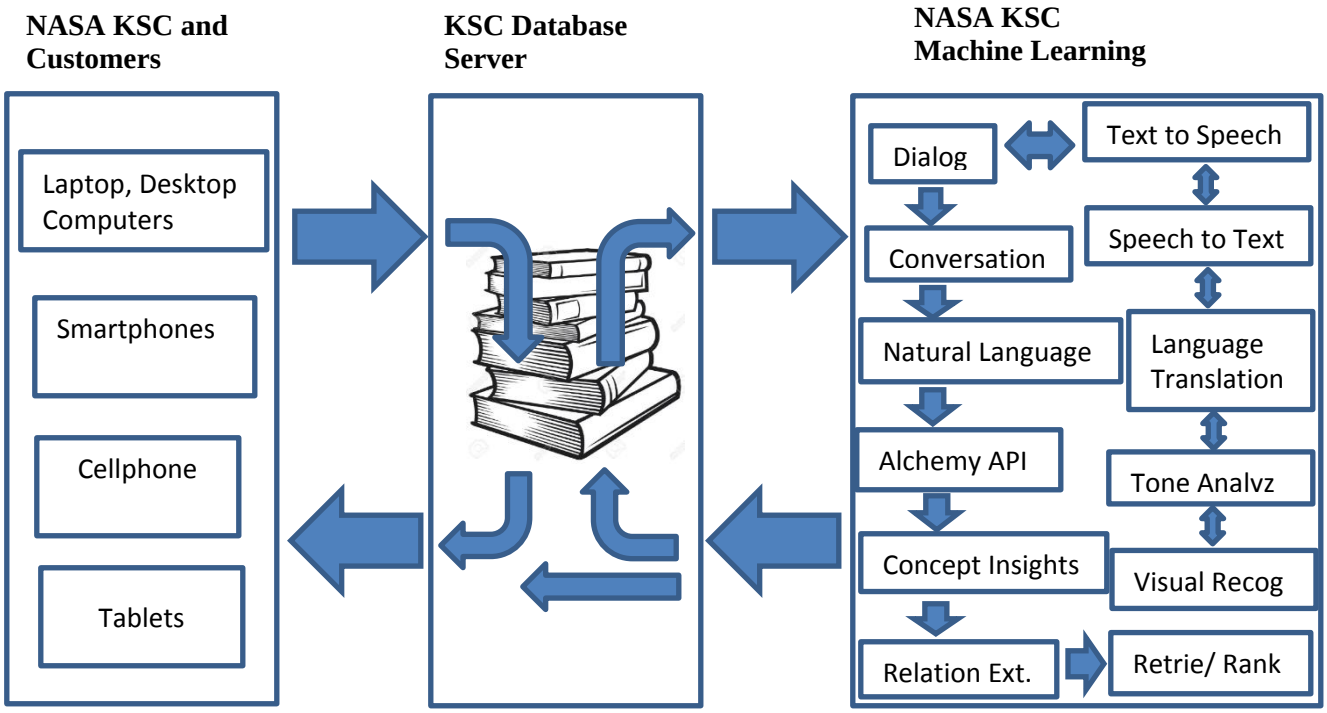


Figure 6. Diagram with interactive communication to provide readings and measurements of technical internal processes at NASA KSC.

Conclusion

Potential applications of IBM Watson cognitive computing tools to the different processes at NASA KSC are attractive and feasible to be implemented due to successful testimonies of similar processes using this technology in different industries to the managed by the aerospace agency. Therefore, the applications found in each of the IBM Watson tools and written in this manuscript are based on the description of each of them and their usage in different study cases found in the internet.

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Acknowledgment

I would like to take this opportunity to thank Dr. Ali Shaykhian and Dr. Dawn Martin to guide and mentor me during my internship this summer 2016 with NASA KSC. My experience was extremely rewarding. In addition to sharpening my writing and editing skills, working in direct contact with the media, and maturing professionally, I thoroughly enjoyed working with such a great team of people. It was a pleasure to watch such amazing results done from my fellow colleagues from scientific processes in the different NASA KSC's facilities.

Also, I would like to thank the different fellows that I have met and provided essential information to increase my knowledge and experience at NASA KSC. My fellow colleagues are included in the following list:

Dr. Orlando Melendez - Office of the Chief Technologist

Dr. Karim J. Courey - Office of Thermal Protection system Facility.

Mr. Wayne Martin - Office of Ground Support Equipment.

Dr. Martha Williams - Spaceport Technology Division

Dr. Luke Roberson - Spaceport Technology Division

Maria Clara Wright - Materials Failure Analysis Laboratory